Preliminary Amendment
Appln. No.: 10/526,031
Attorney Docket No.: Q86579

<u>AMENDMENTS TO THE SPECIFICATION</u>

Please replace the first full paragraph on page 10 with the following amended paragraph:

(4) An abnormality diagnosis system according to (2) or (3), wherein the analyzing portion has a temperature analyzing portion that calculates a temperature of the bearing unit based on the signal output from the ~~data accumulating portion~~ <u>data accumulating/distributing portion,</u> and

the comparing/deciding portion makes the abnormality diagnosis of the bearing unit based on the temperature calculated by the temperature analyzing portion.

Please replace the second full paragraph on page 10 with the following amended paragraph:

(5) An abnormality diagnosis system according to any one of (2) to (4), wherein the analyzing portion has a rotation analyzing portion that calculates a rotation speed of the bearing unit based on the signal output from the ~~data accumulating portion~~<u>data accumulating/distributing portion</u>, and

the comparing/deciding portion makes the abnormality diagnosis of the bearing unit based on the rotation speed calculated by the rotation analyzing portion.

Please replace the second full paragraph on page 13 with the following amended paragraph:

(20) An abnormality diagnosis system according to any one of (1) to (18), wherein the abnormality diagnosis is made at a time different from a vehicle traveling time, based on data accumulated in the ~~accumulating portion~~ data accumulating/distributing portion.

Please replace the third full paragraph on page 31 with the following amended paragraph:

FIG.3 is a view showing the data accumulating/ distributing portion 31 serving as a first data accumulating portion. The data accumulating/distributing portion 31 has a data accumulating portion 31a, a sampling portion ~~31b~~31c, and a sampling reference setting portion ~~31c~~31b. The data accumulating portion 31a is a data saving medium that save the output signals from the sensing elements 22b to 22d every signal, and can be constructed by various memories, the hard disk, and the like.

Please replace the second full paragraph on page 37 with the following amended paragraph:

First, the vibration of the bearing is sensed by the vibration sensing element 22d installed in the ~~sensor unit 22a~~sensor unit case 22a (step S101). The sensed signal is amplified by a predetermined amplification factor and then converted into the digital signal by an A/D converter

(step S102). The vibration signal converted into the digital signal is saved in the data accumulating/ distributing portion 31 in a predetermined format (step S103).

Please replace the second full paragraph on page 38 with the following amended paragraph:

Then, frequencies generated due to the abnormality of the bearing are calculated based on a table shown in FIG.4 (step S110). Then, levels of abnormal frequency components of respective members corresponding to the calculated frequencies, i.e., an inner ring flaw component Si (Zfi), an outer ring flaw component So (Zfc), a rolling element flaw component Sb (2fb), and a ~~retainer component~~retainer flaw component Sc (fc) are extracted (step S111). Then, respective components Si, So, Sb, Sc are compared with the reference value calculated in step S112 (step S113). Then, if all component values are smaller than the reference value, it is decided that no abnormality is generated in the bearing (step S114). In contrast, if any component exceeds the reference value, it is decided that the abnormality is generated in the concerned location (step S115).

Please replace the paragraph bridging pages 38 and 39 with the following amended paragraph:

FIG.10 is a graph showing the frequency spectrum when no abnormality is generated, and FIG.11 is a graph showing the frequency spectrum when the abnormality is generated in the outer ring. In an example in FIG.10, the reference value was derived as –29.3 dB from the

envelope data. If the inner ring flaw component Si(Zfi), the outer ring flaw component So (Zfc), the rolling element flaw component Sb (2fb), and the ~~retainer component~~retainer flaw component Sc (fc) are compared with a line of the reference value depicted in FIG.10, the levels of all components are smaller than the reference value. As a result, it is decided that this bearing is normal. In contrast, in the case in FIG.11, since the outer ring flaw component So (Zfc) is protruded largely from the reference value, it can be decided that the abnormality is generated in the outer ring of the bearing.

Please replace the first paragraph on page 40 with the following amended paragraph:

Since the process flows up to step S108 are similar to those set forth in the method (1), their explanation will be omitted herein. In the present method, first the peak value of the resultant frequency spectrum is calculated (step ~~S109~~S201). Here, in order to derive the peak of the frequency, at first difference data indicating a difference between a level of a data point in each frequency component and a level of a preceding data point in each frequency component is calculated. Then, an inflection point at which a sign of the difference data is changed from plus to minus is found out, and then it is decided that the peak value appears at the frequency values in regarding to the difference data that give positive/negative criterions. In this case, only the frequency spectrum a ridge (inclination) of which shows a steep and sharp peak is selected as the object of the peak values that are necessary for the diagnosis. For this reason, only when a gradient is larger or smaller than a predetermined reference value (e.g., 1 or -1), it is decided that the frequency spectrum gives the peak.

Please replace the first paragraph on page 41 with the following amended paragraph:

Then, the abnormal frequency is calculated from the specification of the bearing based on FIG.4 (step S202). Then, the levels of the abnormal frequency components of respective members corresponding to the calculated frequency, i.e., the inner ring flaw component Si (Zfi), the outer ring flaw component So (Zfc), the rolling element flaw component Sb (2fb), and the ~~retainer component~~retainer flaw component Sc (fc) are extracted (step S203). Then, it is decided by comparing the peak frequency with the frequencies generated at the time of abnormality whether or not the peak frequency agrees with the calculated abnormal frequency (step S204). Then, if a certain peak corresponds to the abnormal frequency, it is decided that the abnormality is generated in the member that corresponds to the concerned abnormal frequency (step S206). In contrast, if the peak corresponds to no frequency, it is decided that no abnormality is generated (step S205).

Please replace the paragraph bridging pages 42 and 43 with the following amended paragraph:

In step S312, it is decided whether or not the spectrum value exceeds the reference value at the frequency of the quaternary component that has the quadruple frequency of the fundamental component generated at the time of abnormality. If the spectrum value exceeds the reference value, it is decided that the quaternary components coincide with each other. Then, in step ~~S321~~S322, it is decided finally that the abnormality is generated in the concerned location.

In contrast, if the quaternary components do not coincide with each other, it is decided finally that the abnormality is not generated in the concerned location.

Please replace the second full paragraph on page 46 with the following amended paragraph:

Then, the final abnormality decision is made by checking whether or not the count number of times indicating that the abnormality is present exceeds the predetermined number of times (step S405). Here, it is decided finally that the abnormality is generated step S406 if the count number of times indicating that the abnormality is present exceeds two times, while it is decided finally that no abnormality is generated step S407 if the count number of times is once or less.

Please replace the paragraph bridging pages 57 and 58 with the following amended paragraph:

The sensor unit ~~60~~61 in the present embodiment has a radio communication device that transmits the output signal fed from the amplifier 50 via radio. An output of the sensor unit ~~60~~61 is sent out to a signal transmitting/receiving device 63 via radio communication.

Please replace the paragraph bridging pages 60 and 61 with the following amended paragraph:

In this abnormality diagnosis system 70, the data accumulating/distributing portion 31 that accumulates the outputs of the sensor units 22 therein is removed from the railway vehicle 65 and then is carried into the information processing center 71 and connected to the calculating/ processing portion 73 in the information processing center 71. Then, various data stored in the data accumulating/distributing portion 31 are analyzed/decided by the calculating/processing portion 73, and then the result outputting portion ~~27~~42 in the controlling/processing portion 75 informs the caretaker, or the like of the decision result and the analyzed result in the calculating/processing portion 73.

Please replace the first paragraph on page 63 with the following amended paragraph:

The physical quantity in the sliding operation (rotating operation) of the bearing 21 as the sliding member is the physical quantity that is changed in response to the rotating condition of the bearing ~~3~~21. For example, various information such as sound and vibration generated by the bearing ~~3~~21, rotation speed and temperature, distortion generated on the constituent parts of the sliding member, and the like may be considered.

Please replace the paragraph bridging pages 63 and 64 with the following amended paragraph:

The reference data that are compared with the analyzed result are various physical quantities that are sensed in the normal condition of the bearing 21 as the diagnosed object by the sensor unit. More particularly, there are information such as frequency components generated by the wear and the failure of the particular location of the bearing ~~3~~<u>21</u>, and the like, in addition to sound information of the normal bearing 21, temperature information of the bearing, vibration information, rotation speed information of the bearing, distortion information generated on the outer ring of the bearing, and others.

Please replace the third paragraph on page 69 with the following amended paragraph:

The piezoelectric sensor 162 detects a vibration acoustic signal generated when the rolling elements (not shown) of the bearing 21 pass over the flaw on the raceway ring (not shown), an AE (acoustic emission) signal generated when the minute crack is developing, or the like, and converts such signal into a voltage or charge signal. The voltage or charge signal is amplified at about 20 to 40 dB by a pre-amplifier (preamplifier circuit) 165 arranged in close vicinity to the piezoelectric sensor 162. Then, the signal after entered into the case ~~161~~<u>161A</u> is converted into a voltage signal, a level of which corresponds to an input range of the A/D converter 154, by the amplifier circuit 153. The voltage signal converted by the amplifier circuit

153 is input into the A/D converter 154 via a bandpass filter (BPF) 166 and then is fed to a predetermined port of the microcomputer including the CPU 152. The A/D converter 154 is an external high-precision A/D converter with a 16-bit resolution.

Please replace the paragraph bridging pages 85 and 86 with the following amended paragraph:

The comparing/deciding portion ~~56~~252 executes the comparison/collation every first time period t_1 by using the above methods (1) to (3) and (5) to (6), and then transmits the provisional diagnosis result about the presence or absence of the abnormality to the internal data saving portion 37 to save the result therein. Also, when the comparing/deciding portion 252 has executed the comparison/decision predetermined number of times or a second time period t_2 that is longer than the first time period t_1 has elapsed, such comparing/deciding portion 252 makes the total evaluation, in which the bearing is considered as the abnormal state when the number of times the bearing is diagnosed provisionally as the abnormality exceeds a threshold value, based on the provisional diagnosis results saved in the internal data saving portion 37, and thus diagnoses the presence or absence of the abnormality in the bearing and its abnormal location.

Please replace the first full paragraph on page 86 with the following amended paragraph:

In this case, the result of each sensed object in the comparing/deciding portion ~~56~~252 may be saved in a storing medium such as memory, HDD, or the like, or the result may be transmitted to the controlling/processing portion ~~60~~40.

Please replace the second full paragraph on page 86 with the following amended paragraph:

The controlling/processing portion 40 has the result outputting portion 42 as a displaying means for displaying the analyzed result and the decision result of the calculating/ processing portions 250, 250 in a predetermined display mode, and the ~~controller~~controlling portion 41 for feeding back the control signal responding to the decision result of the comparing/ deciding portion 252 to the control system that controls the operation of the driving mechanism of the vehicle into which the bearing 211 is fitted.

Please replace the paragraph bridging pages 86 and 87 with the following amended paragraph:

For example, when the decision result of the comparing/ deciding portion 252 indicates that the abnormality is present, the ~~controller~~controlling portion 41 feeds the control signal indicating the travel stop of the vehicle, the reduction of speed, or the like to a travel controller of

the vehicle in response to an extent of the abnormality. In the present embodiment, a plurality of sensor units 22 measures continuously the condition of the bearing of the bearing unit, and the calculating/processing portion 250 conducts sequentially the abnormality diagnosis based on the measured data. Therefore, the controlling/processing portion 40 informs of the abnormality immediately to execute the control of the vehicle when the abnormality occurs. In other words, a flow of sensing, analyzing, deciding, and result outputting are carried out in real time.

Please replace the paragraph bridging pages 89 and 90 with the following amended paragraph:

In addition, in step ~~S114~~<u>S614</u> in FIG.40, the total evaluation in which the presence or absence of the abnormality and its location are decided by comparing the number of times the bearing is provisionally diagnosed as the abnormal state with the threshold value is employed. Alternately, as a variation of the present embodiment, the condition monitoring can be executed by using the total evaluation in which an extent of the damage is decided based on the number of times the bearing is provisionally diagnosed as the abnormal state. As a result, the maintenance can be applied on schedule to the machinery facility an operation of which is not immediately stopped, or the like.

Please replace the first full paragraph on page 92 with the following amended paragraph:

As shown in FIG.42, the sensor unit 22 is fitted to the end surface of the bolt 304 or 305 secured to the surface of the housing 303. The sensor unit 22 can be fitted to the end surface of the bolt 304 used to fix the bearing housing, but the sensor unit may be fitted to the end surface of the bolt 305 used to stop the temperature sensing hole, as described above. Normally this bolt 305 is given to every rolling bearing ~~6~~306 fitted to the inside. For example, in the case of the double row bearing, the fitting location can be selected on the row located on the wheel side, the row located on the motor side, the middle location, or the like according to the purpose. But it is preferable that, for convenience of the fitting operation, the bolt 305 should be fitted to the wheel side and the sensor unit 22 should be provided to the end surface of the bolt 305. Also, the sensor unit 22 can be fitted to not the end surface of the bolt 305 but the side surface or the inside of the hole that is stopped with this bolt 305.

Please replace the second full paragraph on page 106 with the following amended paragraph:

Next, a bearing unit according to a fifteenth embodiment of the present invention will be explained with reference to ~~FIG. 5~~FIG. 49 hereunder. In this case, the same reference symbols are affixed to the portions similar to those in the thirteenth embodiment, and thus their redundant explanations will be omitted or simplified hereunder.

Please replace the paragraph on page 109 with the following amended paragraph:

There is provided the high-precision machinery facility ~~abnormality monitoring system~~abnormality diagnosis system that is capable of deciding the presence or absence of the abnormality in the state of normal use without decomposition of the facility like the machinery facility such as a railway vehicle facility, a machine tool, a windmill, or the like, which requires much time and labor to decompose, and thus capable of reducing the maintenance/ administrative costs and being hardly affected by the noise, and the like.